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### Concussion in motorsport? Experience, knowledge, attitudes and priorities of medical personnel and drivers

**Citation for published version:**

Adams, S, Turner, A, Richards, H & Hutchinson, PJ 2018, 'Concussion in motorsport? Experience, knowledge, attitudes and priorities of medical personnel and drivers', *Clinical Journal of Sport Medicine*.  
<https://doi.org/10.1097/JSM.0000000000000647>

**Digital Object Identifier (DOI):**

[10.1097/JSM.0000000000000647](https://doi.org/10.1097/JSM.0000000000000647)

**Link:**

[Link to publication record in Edinburgh Research Explorer](#)

**Document Version:**

Peer reviewed version

**Published In:**

Clinical Journal of Sport Medicine

**Publisher Rights Statement:**

This is the accepted version of the following article: Adams. (2018). Concussion in Motorsport? Experience, Knowledge, Attitudes, and Priorities of Medical Personnel and Drivers. Clinical Journal of Sport Medicine, which has been published in final form at: <https://doi.org/10.1097/JSM.0000000000000647>

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# CONCUSSION IN MOTORSPORT

Concussion in Motorsport? Experience, Knowledge, Attitudes and Priorities of  
Medical Personnel and Drivers

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**Acknowledgments:** The authors would like to thank Dr Paul Trafford, Dr Ian  
Roberts and the motorsport drivers who provided consultation. We would also like to  
thank Louise Finlayson and Gala Morozova for their support and assistance in  
completing this study, as well as the UK Motor Sport Association (MSA) and Scottish  
Motor Sports (SMS) staff who helped to advertise the online survey.

**Conflicts of Interest and Source of Funding:** PJH is Chief Medical Officer for the  
FIA Formula One British Grand Prix at Silverstone. Stephanie Adams is supported  
by a University of Edinburgh Principal's Career Development Scholarship. Nothing  
declared for the remaining authors.

**Main word count:** 3,053

**Abstract word count:** 269

### 39 **Abstract**

40 **Objective:** To assess concussion experiences, knowledge and attitudes of  
41 motorsport medical personnel and drivers, and to determine priority areas regarding  
42 concussion within the sport.

43 **Design:** Sequential mixed-methods design. Part 1: Stakeholder interviews; Part 2:  
44 Cross-sectional online survey.

45 **Setting:** United Kingdom.

46 **Participants:** Part 1: Key motorsport stakeholders ( $N=8$ ); Part 2: Motorsport medical  
47 personnel and drivers ( $N=209$ ) representing amateur and/or professional 4-wheeled  
48 motorsport.

49 **Main Outcome Measures:** Concussion experience, knowledge, attitudes and  
50 perceived priority areas.

51 **Results:** Thirty-one percent of surveyed drivers (age =  $37.91 \pm 13.49$  years: 89%  
52 male) reported suffering from concussion in motorsport. Eighty-seven percent of  
53 surveyed medical personnel (age =  $48.60 \pm 10.68$  years: 74% male) reported  
54 experience with concussed drivers and 34% reported feeling pressured to clear a  
55 driver with concussion. Gaps in knowledge and misperceptions about concussion  
56 were reported in both groups, and disparity between concussion attitudes emerged  
57 between drivers and medical personnel. Application of assessment and  
58 management procedures varied between medical personnel and there was evidence  
59 motorsport policy and concussion guidelines may not be directly followed. According  
60 to both medical personnel (77%) and drivers (85%), 'education and training' is the  
61 top priority area for the sport.

62 **Conclusions:** There is clear evidence of concussions in motorsport, but accurate  
63 knowledge about this injury is missing. Concussion education and training for all

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64 drivers and medical personnel is required. Additional investigations into concussion  
65 attitudes are advised to complement and advance simple educational initiatives.  
66 Further investigation is also required to determine how to best support motorsport  
67 medical personnel, and general practitioners, who hold significant responsibility in  
68 guiding drivers from diagnosis to return-to-racing, and to support the effective  
69 implementation of policy.

70 **Key Words:** concussion, motor sports, motorsport, stakeholders, knowledge,  
71 attitudes.

72 **Clinical Relevance:** Concussion in motorsport is a concern, and relevant  
73 information, guidelines and policy may not be effectively reaching motorsport  
74 medical personnel and drivers.

### 75 INTRODUCTION

76 Sport concussion is a current, high priority issue affecting millions of individuals  
77 worldwide<sup>1</sup>, including motorsport athletes (e.g., Formula-1, rally)<sup>2</sup>. Drivers are  
78 frequently subjected to demands that are rare in other sports (e.g., excessive  
79 speeds, high G forces, large rotational mechanisms)<sup>2,3</sup>. The risk and incidence of  
80 concussion in motorsport have been reported as high, and rising<sup>2,4</sup>.  
81 However, published evidence of the experiences, knowledge and attitudes of key  
82 motorsport stakeholders (e.g., medical personnel, drivers) is lacking, and there is a  
83 significant knowledge gap regarding concussion in motorsport specifically<sup>5</sup>.

84 Motorsport has more than 80 million people involved worldwide<sup>6</sup> and an  
85 increasing number of younger participants entering the sport<sup>5</sup>. The exact number of  
86 drivers is unknown, because unlicensed drivers may be three times the number of  
87 licensed at any one time<sup>7</sup>. The UK alone reports approximately 30,000 licenced  
88 drivers each year<sup>8</sup>. There are specific challenges within the context of motorsport  
89 including that the sport can be highly independent, with many drivers traveling to and  
90 from races alone, without a coach or family member. Furthermore, the availability of  
91 on-site medical personnel and medical resources varies significantly across region,  
92 race series and level, making standardised concussion management challenging. A  
93 detailed description of the specific components of motorsport is beyond the scope of  
94 this paper, however, relevant information can be found at [www.msauk.org](http://www.msauk.org).

95 Recently there has been an increase in concern about concussion in  
96 motorsport reflecting high profile incidences<sup>9</sup>, governing body policy<sup>10</sup>, media  
97 publications<sup>11-13</sup> and developing research in other sports. Consequently, early stage  
98 research into incidence and engineering perspectives have emerged<sup>2,5</sup>.

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Research in other sports has identified gaps in athletes' knowledge, and attitudes, towards concussion<sup>14-18</sup>. Similarly, medical professionals have demonstrated substantial gaps in knowledge, and misperceptions<sup>19-21</sup>. Physician knowledge about concussion is essential, particularly given they remain the primary health care provider for concussion<sup>22</sup>. Limited evidence of knowledge towards concussion exists in two-wheeled motorsport<sup>23</sup>, but to date, there have been no peer-reviewed studies of knowledge, or attitudes, towards concussion within four-wheeled motorsport.

Stakeholder involvement develops local relevance<sup>24</sup>, improves research uptake<sup>25</sup> and is a valuable component of the processes leading to effective interventions<sup>26</sup>. Involving stakeholders in helping to identify research priorities has proven effective in other areas of medicine and sport, such as nursing<sup>27</sup>, paediatrics<sup>28</sup>, health promotion, and sport injury prevention<sup>29,30</sup>. To our knowledge, stakeholders', in this case motorsport drivers and medical personnel, perceived priority areas regarding concussion remain largely unaddressed, meaning contextualised perspective on this issue is lacking.

The aim of this research was to assess context and establish research feasibility and direction, followed by further assessment of concussion experiences, knowledge, attitudes and perceived priority areas for development in motorsport.

### **METHODS**

A sequential mixed-methods design<sup>31</sup> was used. Qualitative interviews (Part 1) explored stakeholders' views and experiences. This informed a survey (Part 2) developed to assess experiences, knowledge, attitudes, and perceived priority areas. Research was approved by the relevant institutional ethics committee.

### **Part 1**

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Eight experienced stakeholders (4 medical personnel (*MED*), 4 drivers (*DRIV*); aged 18+ years, *M*=40), with a mean 18 years of experience (range = 5 - 28 years), gave informed consent to be interviewed. Stakeholders were purposively sampled to be representative of different disciplines, roles and levels of motorsport (see Table, Supplemental Digital Content), and included highly accredited medical personnel and drivers at the professional level of the sport.

A semi-structured interview guide was developed through an iterative process of revision and piloting, using an expert panel (*N*=4) including qualitative researchers and a former international motorsport driver. Individual interviews (*M*= 30 minutes) were recorded and transcribed using unique pseudonyms, and member checking<sup>32</sup> was used to improve confidence in quality of data. Thematic analysis was conducted<sup>33</sup> and consensus validation<sup>34</sup> was used to establish validity and trustworthiness, achieving 86% initial agreement prior to researcher discussions which resolved any discrepancies.

### **Part 2**

An online cross-sectional survey was disseminated using Bristol Online Survey (BOS; <https://www.onlinesurveys.ac.uk/>). Prior to launching, the survey went through multiple stages of revision and piloting. Content and face validity were checked by motorsport medical experts and professional motorsport drivers. The survey was disseminated UK-wide via national governing body mailing lists, newsletters, websites and postings on social media. Inclusion criteria included being 16+ years of age, and either a racing licenced UK driver or medical personnel (including UK certified doctors, surgeons, paramedics) from 4-wheeled motorsport.

Surveys contained a 24-item sign/symptom checklist (including distractors) and 18 statements, to assess concussion knowledge and opinions, adapted from a

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previous survey<sup>35</sup>. Checklist items reflected all different categories of signs/symptoms (i.e., physical, cognitive, emotional and sleep)<sup>36</sup>. Attitudes towards concussion were assessed using scenario-based questions from the Rosenbaum Concussion Knowledge and Attitude Survey (RoCKAS)<sup>37</sup>, which were adapted to suit motorsport context. Scoring and interpretation of these sections followed guidance from previous publications<sup>35,37</sup>.

Medical personnel completed open-ended questions about concussion assessment and management practices (e.g., “How would you assess someone with a suspected concussion?”), adapted from the literature<sup>38</sup>. Additionally, all participants were instructed to describe two perceived priority areas regarding concussion in motorsport.

Quantitative analyses were performed using SPSS Statistics version 22.0 (SPSS, Inc.), with an a priori significance level of  $p < 0.05$ . Normality and equality of variance assumptions (Shapiro-Wilk’s and Levene’s tests respectively) were met for general knowledge statements as well as the attitude scenarios. T-tests were therefore used to assess differences in general knowledge, and attitude scenarios, between groups (MED, DRIV). Sign/symptom data did not meet normality assumptions, and so a Mann-Whitney U test was used to assess sign/symptom knowledge between groups. Qualitative survey questions were analysed using thematic analysis<sup>33,34</sup>.

## RESULTS

### Part 1

The following themes describe the current state of concussion in motorsport:

#### *Concussions occurrence*



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All MED reported working with concussion in motorsport. One MED also described working with drivers with on-going symptoms and related-challenges:

“...seen drivers as a clinical follow-up who have been concussed, with on-going symptoms and issues with decision-making etc” (MED3).

Two of four drivers described personal experiences of concussion and three described indirect experiences through teammates or friends (Table 1).

### *Potential underdiagnoses/underreporting*

Participants described signs of concussion including periods of transient dysfunction following accidents, and feelings of the brain being “shaken”. One driver indicated they might delay symptom reporting, or not seek medical help at all (Table 1). Additionally, MED articulated concerns about the consequences associated with underdiagnosis or underreporting:

“my fear is you have somebody who is not really in control of their faculties... they’re drowsy, not able to think clearly... if they go back in that car, they’re potentially going to kill themselves or kill somebody else” (MED1).

They also noted that concussion is likely under-recognised in general, and from a media perspective:

“it’s perhaps not as well-known from the public’s point of view, it’s not seen on camera as much as it is in rugby, American football... on a track if there’s something really big they just turn the camera away...” (MED4).

### *Challenges & variation in diagnosis, assessment and management*

Reported concussion assessment and management practice differed according to motorsport series and/or level (Table 1). In addition, two MED (who regularly work in general practice) were concerned about general practitioners’

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(GPs) “lack of concussion knowledge”, particularly given recent UK motorsport policy<sup>10</sup> that requires concussed drivers to seek GP clearance before returning to competition:

“unreasonable to ask [GPs] to write a letter to say this guy’s better from this concussion... GPs haven’t got a clue we don’t see concussion in general practice” (Med1).

[Table 1]

The following themes reflect recommended future directions and requirements:

### *Role of governing bodies*

All participants advocated for governing bodies to be heavily involved in supporting and actively implementing research findings (Table 2).

### *Education and training*

All DRIV, and two MED, emphasised a need to disseminate concussion-related information and/or education, and mandatory education was also suggested (Table 2).

### *Motorsport-specific research*

Two drivers emphasised pushing for more sport-specific research, as they believed it is currently lacking:

“so far things with concussion are not as researched and understood [in motorsport]” (DRIV2).

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This was echoed by medical personnel. Specifically, they felt data is needed to enhance diagnosis, assessment and management procedures (Table 2).

### *Engineering and technology*

Two drivers prioritised focusing on safety technology (e.g., helmets) and one MED prioritised continued improvements to track-design and safety equipment (Table 2).

### **Part 1 summary**

Motorsport experts have significant experience with concussion and the injury may be underdiagnosed. Motorsport MED (and GPs in general) may be behind other sports in terms of assessment and management practices, and implementing recent policy<sup>10</sup>. In general, the sport may have limited information and knowledge about concussion. Top perceived priority areas include education and training, acquiring motor-sport specific data and focusing on collective action between researchers, medical professionals and governing bodies.

[Table 2]

### **Part 2**

Two hundred and nine respondents (90 MED, 119 DRIV) completed the survey. One MED and 18 DRIV did not meet inclusion criteria, thus their data was excluded from analyses. The majority of participants were male (74% MED, 89% DRIV). Forty-eight percent of MED were qualified medical doctors. Seventy-five percent of drivers were amateur level, and 78.7% of MED worked both amateur and professional level events. Respondents represented multiple types of motorsport, 'Circuit racing'

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(65.2% MED, 25.7% DRIV) and 'Rallying' (27.0% MED, 42.6% DRIV) were the most common (see Tables, Supplemental Digital Content).

Thirty-one percent of drivers reported concussion during motorsport. Eighty-seven percent of MED reported working with concussed drivers. Thirty-four percent of MED have felt pressured to clear a concussed driver.

Medical personnel demonstrated significantly greater sign/symptom knowledge ( $M=20.27$ ,  $SD=2.14$ ;  $U=2,077.0$ ,  $p<0.001$ ,  $r=0.48$ ) compared to drivers ( $M=16.76$ ,  $SD=4.04$ ). Inspection of individual checklist items revealed knowledge gaps. For example, few DRIV correctly identified 'sadness' (35.6%), 'trouble falling asleep' (41.6%) and 'feeling more emotional' (47.5%). Overall, both groups identified fewer 'emotional/sleep' items. Furthermore, 'shortness of breath' (20.2% MED, 18% DRIV) and 'ear discharge' (32.6% MED, 36% DRIV) were incorrectly thought to be signs of concussion (Figure 1).

Medical personnel demonstrated significantly greater general concussion knowledge ( $M=72.87$ ,  $SD=6.06$ ;  $t(187)=9.03$ ,  $p<0.001$ ,  $d=1.32$ ) compared to drivers ( $M=64.80$ ,  $SD=6.19$ ). However, both groups indicated several misperceptions. The most common were uncertainty about the recovery time for younger drivers (37.1% MED, 52.0% DRIV) and uncertainty whether prior concussion increases the risk of another concussion (37.1% MED, 35.6% DRIV). Furthermore, DRIV incorrectly agreed protective equipment (e.g., helmet) prevents concussion and that standard brain imaging (e.g., CT scan) shows concussion damage (26.7% and 23.8%, respectively). DRIV (50.5%) and MED (42.7%) incorrectly agreed drivers can start normal training when they are symptom free (Table 3). Furthermore, few participants (67.4% MED, 23.8% DRIV) 'strongly disagreed' that concussion can only occur from a direct blow to the head. Finally, 50.5% of DRIV and 42.7% of MED incorrectly

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believed drivers can start normal training as soon as they are symptom free (Table 3).

[Figure 1]

Analysis of the adapted RoCKAS scenarios revealed no significant group differences in mean attitude scores ( $t(185)=1.31$ ,  $p=0.19$ ,  $d=0.19$ ; DRIV:  $M=40.56$ ,  $SD=4.61$ , MED:  $M=39.67$ ,  $SD=4.61$ ). When participants responded about their own attitudes, both groups demonstrated moderately safe attitudes towards concussion. However, variation was introduced when MED were asked to comment on what 'most drivers would feel' (Table 4 & see Table, Supplemental Digital Content).

[Table 3]

Analysis of open-ended questions showed forty-eight percent of MED find concussion assessment difficult. 'Complexities of symptoms and diagnosis' were the most commonly reported reasons, followed by 'driver/team behaviours/pressures to compete' and 'logistical challenges (time/location/facilities)' (see Table, Supplemental Digital Content).

[Table 4]

Medical Personnel (76%) reported using subjective and objective assessment approaches (24% of whom reported using a combination of both). Few MED

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acknowledged following concussion policy and two MED reported adopting the World Rugby guidelines while working in motorsports. A number of findings highlight violation of recent consensus guideline<sup>39</sup> and UK motorsport policy<sup>10</sup>. For example, few MED (8%) reported recommending drivers follow a graduated return-to-sport protocol. Additionally, few MED reported telling drivers they should see their GP, or ensuring drivers are removed from competition until recovered and/or having the driver's licence temporarily suspended (12% and 28%, respectively) (Table 5).

[Table 5]

Thematic analysis revealed that the top three priority areas surrounding concussion in motorsport included: (1) 'Education/training' (MED=77%, DRIV=85%); (2) 'Clearer concussion policy/procedures' (MED=30%, DRIV=24%); (3) 'Improving assessment procedures' (MED=28%, DRIV=10%).

### **Part 2 summary**

Eighty-seven percent of surveyed MED and 32% of DRIV reported concussion experiences, and 34% of MED reported feeling pressured to clear a concussed driver to return-to-sport. MED outperformed drivers (as expected) on both sign/symptom identification and general knowledge statements. However, both groups showed knowledge gaps. Although no significant group differences existed in regards to participants' attitudes towards concussion, MED indicated negative expectations of drivers' intentions. Medical personnel may benefit from support to improve adherence to motorsport concussion policy. 'Education/training' was the most highly reported priority within the sport.

**DISCUSSION**

This mixed-methods study represents the first examination of concussion knowledge and experiences within (four-wheeled) UK motorsport. It is also the first assessment of concussion attitudes across motorsport, and, is believed to be the first to conduct stakeholder interviews to help direct a sport-specific research agenda on concussion and to build justification for subsequent survey investigation.

Concussion in motorsport may be more common than expected. A third of surveyed drivers and 87% of medical personnel reported concussion experiences. These findings are consistent with recent literature<sup>2</sup>, including a pilot survey that found 90% of medical staff (31 countries) reported concussion experiences<sup>11</sup>. Stakeholders indicated that motorsport may be experiencing underreporting and underdiagnosis similar to other sports<sup>1</sup> (see Table 1). Behaviours and processes for reporting, and non-reporting, in motorsport should be investigated further.

Attitudes have a significant role in guiding behaviours<sup>40</sup>, and whilst participants demonstrated relatively safe attitudes towards concussion, on average, medical personnel showed evidence they did not believe most drivers always respond in the safest manner. In contrast, drivers generally thought they, and other drivers, would respond safely to concussion. It could be that drivers responded in a socially desirable manner. Previous research found athletes demonstrated safe concussion attitudes when assessed using questionnaires but revealed unsafe behaviours during follow-up interviews<sup>16</sup>. These findings have implications for how concussion attitudes are assessed, and prompts further questions around the medical personnel and athlete relationship. Additional investigation is warranted and alternative methods of assessing attitudes, such as through implicit measures<sup>41</sup>, would significantly enhance quality of evidence.

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Drivers demonstrated worse sign/symptom knowledge compared to MED and performed up to 22% worse compared to other surveyed athlete groups<sup>14-17,23</sup>. Both groups identified fewer 'emotional-sleep' signs/symptoms of concussion compared to 'cognitive' or 'physical' items, consistent with previous surveys<sup>14,35,38,42</sup>. Interestingly, more drivers correctly identified the 'red flag' signs of concussion (seizure or convulsion, neck pain) than MED<sup>43</sup>. There is a need to improve sign/symptom identification within motorsport and such knowledge gaps should feature in interventions.

Participants reported misperceptions consistent with earlier literature in other sports<sup>35</sup>. For example, a number of respondents incorrectly believed scans (e.g., X-ray) show concussion-induced damage to the brain and that protective equipment (e.g., helmet) prevents concussion. In fact, some participants regarded personal protective equipment as a priority in addressing concussion in motorsport, demonstrating lack of awareness that items like helmets may not reduce concussion incidence or severity<sup>36,44</sup>. Additionally, few participants understood that younger individuals (under 18 years) typically take longer than adults to recover from concussion. Drivers incorrectly agreed that concussions only occur from a direct blow to the head and that drivers have to lose consciousness to be diagnosed with concussion. In motorsport specifically, significant rotational forces (which can lead to concussion) are common even without direct impact or loss of consciousness<sup>2</sup>.

Medical personnel, GPs in particular, are the gatekeepers between drivers and their return to racing. However, present findings suggest recent policy<sup>10,39</sup> may not be reaching medical personnel. Few MED discussed the importance of a return-to-sport protocol, ensuring drivers are removed from competition with a temporarily



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suspended licence or that drivers follow-up with a GP, which are all key points of UK motorsport concussion policy<sup>10</sup> and consensus guidelines<sup>39</sup>.

Furthermore, the current guidance to see a general practitioner, and the finding that 40% of MED in the current study immediately refer patients to hospital for concussion, may be a concern. Studies suggest UK emergency department physicians lack concussion knowledge<sup>45</sup> and that general practitioners show inadequacies in concussion-related knowledge and practice<sup>19,21,22,46</sup> despite being the primary health resource for concussed individuals<sup>21</sup>. To alleviate this concern, and the burden placed on general practice and emergency departments, the UK may benefit from adopting the North American practice of sport concussion clinics, where highly trained multidisciplinary teams specialise in dealing with concussion cases.

Thirty percent of MED in the current study reported zero training or education on concussion, which may help to explain the limited adherence to concussion policy. A 2012 Canadian study found only 29% of its medical programmes provided any form of concussion education and that medical students lacked concussion knowledge<sup>46</sup>, similar to the current findings. Further work is needed to support motorsport medical personnel, and possibly GPs in general. Concussion education has now been successfully integrated into medical curricula in other countries<sup>19</sup> and may be needed in UK programmes. Ensuring MED are educated about concussion (and updated as things progress) will likely improve concussion-related care<sup>21</sup>, simultaneously addressing other top priorities from the current survey (i.e., ‘assessment practices’, ‘clear concussions policy/procedures’).

Education and training are clearly top priorities for motorsport. Concussion education is advocated as a highly effective part of addressing the problem of sports concussion and has shown improvements in other sports<sup>47</sup>. Interviewed stakeholders

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in the current study also perceived developing safety equipment and technology as key priorities. However, new developments take significant resources, and years, before implementation even at the top levels of motorsport (e.g., the ‘Halo’ system designed to guard drivers against airborne debris<sup>48</sup>). More specifically, advancements in engineering may not be effective, or plausible in cost or time to efficiently address concussion issues. Consequently education and training, which could be quickly made available to all levels of the sport, should be prioritised.

The survey was widely distributed across the UK however there may be a self-selection bias; people who already knew, or held personal interest, about concussion may have been more likely to respond. Additionally, accurate response rates could not be quantified given the described recruitment methods. Participants’ reported concussion history could not be validated using medical records. Finally, the research was specific to the UK and therefore should not be generalised to other countries or two-wheeled motorsports.

In summary, this research helps to address the existing knowledge gap for concussion in motorsport specifically, and highlights several concussion issues in the sport including misperceptions and gaps in knowledge, and limited adherence to concussion policy and guidelines. Education and training for drivers (currently underway) and medical personnel is needed. Findings also extend beyond motorsport, indicating a potential need to review current medical programmes to ensure structured training and continued educational opportunities on sports concussion as well as further consideration of the role for UK sports concussion clinics.

418 **Acknowledgments:** The authors would like to thank Dr Paul Trafford, Dr Ian  
419 Roberts and the motorsport drivers who provided consultation. We would also like to  
420 thank Louise Finlayson and Gala Morozova for their support and assistance in  
421 completing this study, as well as the UK Motor Sport Association (MSA) and Scottish  
422 Motor Sports (SMS) staff who helped to advertise the online survey.

423 **Contributors:** SAA led the design, conduct, analysis and drafting of the manuscript.  
424 APT, HR and PJH also contributed to research design, analysis interpretation and  
425 editorial input for the manuscript.

426 **Conflicts of interest and source of funding:** PJH is Chief Medical Officer for the  
427 FIA Formula One British Grand Prix at Silverstone. Stephanie Adams is supported  
428 by a University of Edinburgh Principal's Career Development Scholarship. Nothing  
429 declared for the remaining authors.

430 **Ethics approval:** Moray House School of Education Ethics Committee, University of  
431 Edinburgh.

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553  
554

555 **Figure legends:**

556 **FIGURE 1.** Percentage of Correctly Identified Concussion Signs and Symptoms by

557 Motorsport Medical Personnel (MED;  $N=89$ ) and Drivers (DRIV;  $N=101$ ).

558

## CONCUSSION IN MOTORSPORT

559 **Table legends:**

560 **\*Please also see separate Table file.**

561

562 *Table title:* **TABLE 1.** Current State of Concussion in Motorsport

563 *Appropriate column heads:* **Main theme; Sub-theme with sample quotes; No. of**  
564 **participants who endorsed this**

565 *Explanatory legends: Note.* N=8, MED=Medical personnel, DRIV=Drivers.

566

567 *Table title:* **TABLE 2.** Future Directions and Requirements in Motorsport

568 *Appropriate column heads:* **Key theme; Sub-theme with sample quotes; No. of**  
569 **participants who endorsed this**

570 *Explanatory legends: Note.* N=8, MED=Medical personnel, DRIV=Drivers.

571

572 *Table title:* **TABLE 3.** General Gaps in Knowledge and Opinion Identified in

573 Motorsport Medical Personnel (MED; N=89) and Drivers (DRIV; N=101)

574 *Appropriate column heads:* **Statement; Responses (%), Strongly disagree,**  
575 **Disagree, Neutral, Agree, Strongly Agree**

576 *Explanatory legends: Note.* Key knowledge gaps are in bold. Items 8-14, 16-17 are  
577 reverse scored. Distractor items not presented. MED=Medical personnel,  
578 DRIV=Drivers.

579

580 *Table title:* **TABLE 4.** Concussion Attitudes According to Scenario-Based Questions

581 *Appropriate column heads:* **Statement; Responses (%), Strongly disagree,**  
582 **Disagree, Neutral, Agree, Strongly Agree**

## CONCUSSION IN MOTORSPORT

583 *Explanatory legends: Note.* Responses (%) = percentage of MED/DRIV who rated  
584 each particular item as such, MED=Medical personnel, DRIV=Drivers. See  
585 Supplemental Digital Content for full scenarios. Safer attitudes are in bold. Scenario  
586 **2** is reverse scored. Participants received 1-5 points for each item, 5 points  
587 representing safest possible answer and 1 point representing least safe answer.  
588 Possible scores ranged from 10-50, higher scores representing safer attitudes  
589 towards concussion.

590

591 *Table title:* **TABLE 5.** Concussion Assessment & Management Practices Amongst  
592 Motorsport Medical Personnel

593 *Appropriate column heads:* **Assessment approach; No. (%) of respondents;**  
594 **Management approach; No. (%) of respondents**

595 *Explanatory legends: Note.* No. (%) of respondents=number of medical personnel  
596 who endorsed the item. Analysis based on responses from *N*=68 doctors. Multiple  
597 items sometimes suggested by respondent, thus % exceeds 100 and No. exceeds  
598 *N*.

599

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600 **Supplemental Digital Content:**

601 Supplemental Digital Content 1\_Adams et al.\_Concussion in motorsport.pdf